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A COST-EFFECTIVENESS STUDY OF PARTICULATE AND SO_x EMISSION CONTROL IN THE NEW YORK METROPOLITAN AREA

Ernst and Ernst

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Summary Statement by Ernst & Ernst to the

New York Air Pollution Abatement Conference

February, 1968

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I. INTRODUCTION

Mr. Presiding Officer, conference members, ladies and gentlemen. My name is Joseph K. Barry. I am the partner in charge of Management Services in the New York Office of Ernst & Ernst, a certified public accounting firm.

We will present today the principal results of a contract study for the U. S. Public Health Service to develop, under certain assumptions, broad estimates of the cost of reducing particulate and sulfur oxides (SO_x) emissions from several kinds of power plants, stationary combustion sources, and incinerators which may be found in the New York Metropolitan Area.

The study developed and applied a computerized analytical technique to calculate the estimated annual costs of emission control alternatives applicable to models of these sources. The costs and efficiencies of the control alternatives were developed from an analysis of data reflecting actual control experience. Since these data were originally compiled by others and were not subject to our independent verification, our results should be viewed as magnitudes, or general levels, of cost rather than as precise figures. These results, and others which the analytical technique is capable of providing, can aid in the formulation of approaches to air pollution abatement in the New York Metropolitan Area.

I would like now to introduce Mr. Ellison S. Burton of the Washington Office of Ernst & Ernst who has been the project director of the study and who will present the study results.

II. SUMMARY OF STUDY RESULTS

Thank you, Mr. Barry. Mr. Presiding Officer, conference members, ladies and gentlemen. My name is Ellison S. Burton. I am a member of the Management Services Division of Ernst & Ernst and the project director of our study for the Public Health Service.

Mr. Barry mentioned that the objective of this study is to estimate the annual cost of reducing particulate and SO_x emissions from models of power plants, stationary combustion sources, and incinerators. The numerical data providing the basis for the study have come from agencies of the Federal, state, and local governments, manufacturers of emission control equipment, public utilities, trade associations, fuel suppliers, consultants, and others. The Public Health Service, in particular, provided much of the detailed data on emission rates, emission source characteristics, and control devices.

I'll proceed by describing the emission control alternatives postulated for uncontrolled sources, and then the estimated annual cost of emission reduction based on these alternatives for the several kinds of power plants, stationary combustion sources, and incinerators modeled. But, first, some definitions are needed. By the term "power plant" we mean a steam electric generating station which sells electrical power to the general community. By "stationary combustion source" we mean a power or heating plant which could be found in an industrial or commercial location, or in a large apartment house. By "incinerator" we mean a large municipal incinerator. Characteristics of the power plants and

other stationary combustion sources modeled are given in the appendix to the verbatim statement distributed to the conferees and to others on request. The incinerator model is described in the following discussion. It is assumed as a base condition that the sulfur content of fuels used by uncontrolled sources is 2% by weight for coal and 2.5% by weight for residual oil.

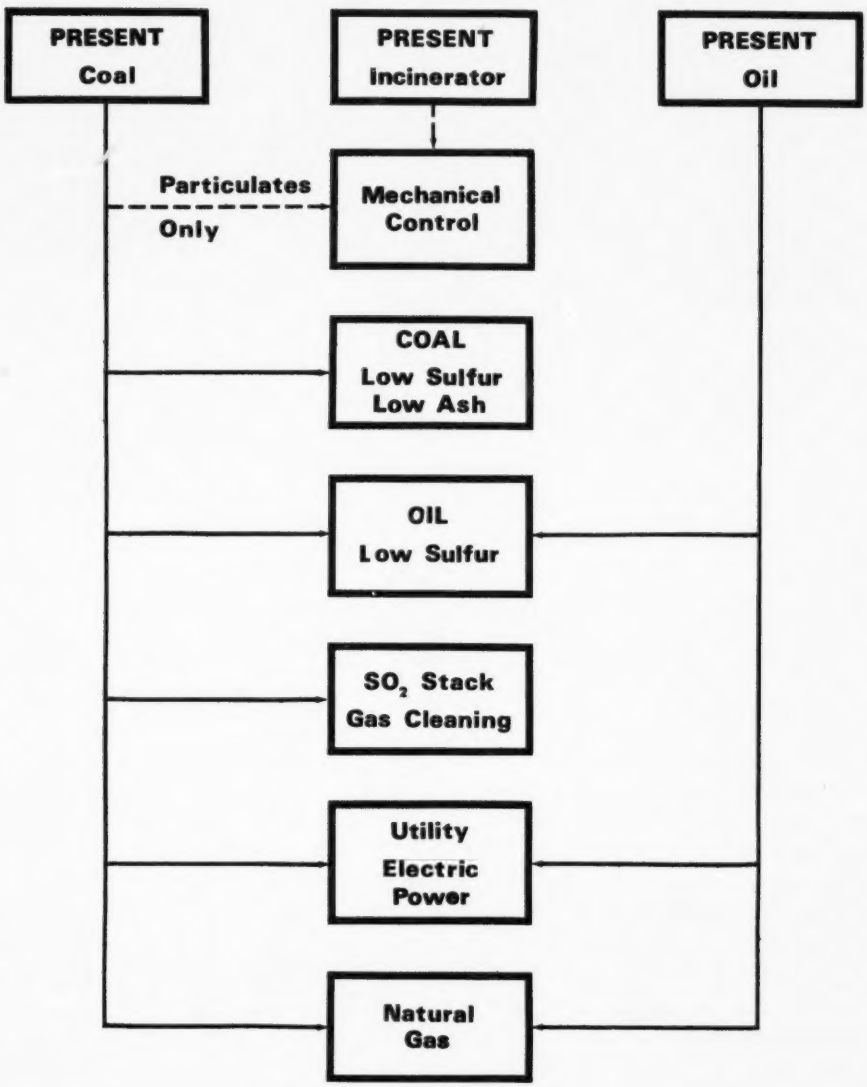
Even though this session of the abatement conference is concerned primarily with particulate pollution, discussion of particulate emission control from power plants and stationary combustion sources must involve discussion of the control of SO_x as well. The reason is that several of the alternatives for SO_x control also involve control of particulates. In general, therefore, it is not possible to estimate the cost of controlling each pollutant independently. In this study, emission control alternatives and their costs are discussed in terms of the simultaneous control of both pollutants.

First slide, please. (Figure 1)

This diagram shows the fuel and hardware alternatives assumed to be available to uncontrolled power plants, stationary combustion sources, and incinerators modeled in this study. Suppose a source is presently burning a 2% sulfur coal and has no particulate control, then there are a number of alternatives for reducing particulate and SO_x emissions. For example, a mechanical collector could be installed. Another device, an electrostatic precipitator, could be added in series with the collector to increase particulate reduction to as much as 99.5% of uncontrolled emissions. To reduce SO_x emissions, a lower sulfur coal, say, 1.5%, 1%

FIGURE 1

ALTERNATIVES FOR SO_x AND PARTICULATE EMISSION CONTROL (COMBUSTION SOURCES)



or 1/2% could be substituted. Other alternatives were also postulated; for example, a power plant could retain its present coal and install an SO_2 stack gas cleaning system. Another possibility is to switch from coal to residual oil at 2.5%, 2%, 1.5%, 1% or 1/2% sulfur. For a stationary combustion source, still a further possibility is to switch to natural gas, or if the function of the source is to generate electrical power, electricity could be purchased directly from a utility. Some alternatives were not considered, such as switching to atomic energy.

The cost and effectiveness of each feasible emission control alternative were developed for the sources modeled. The alternatives were then ranked according to increasing cost. The different sulfur levels of fuels together with the different efficiency levels of hardware postulated generate up to fifty choices for some source models to control both particulate and SO_x emissions. A maximum of five choices for each source were selected for this presentation to cover a broad spectrum of possible costs and emission reductions.

Ranges of cost were estimated for each alternative, broken down into cost per BTU for fuels; purchase, installation, maintenance and operating costs for mechanical equipment, and boiler conversion costs, where required, for switching types of fuels. A 15 year write-off of capital costs is assumed. Methods of financing capital costs and attendant interest charges were not considered in this study. It should be understood that the costs presented are incremental costs; that is, they are to be added to any present annual operating cost assumed.

We turn now to the results of this analysis.

Next slide, please. (Source Model 1)

In this figure and in others that follow, the percentage reduction in particulate emissions is shown on the vertical axis and the percentage reduction in SO_x emissions is shown on the horizontal axis. The numbered points give the simultaneous particulate and SO_x emission reductions effected by the correspondingly numbered emission control alternatives. The estimated annual cost of each control alternative is given in bold type at the bottom of each figure. The middle estimate is considered to be the most likely cost on the basis of the data available. Again, these costs are in addition to a present annual operating cost. High and low estimates are also given to reflect both uncertainties and variances in current prices for fuels, and for purchase, installation, maintenance and operation of mechanical controls. Descriptions of all alternatives shown in these figures are given in the appendix to our verbatim statement.

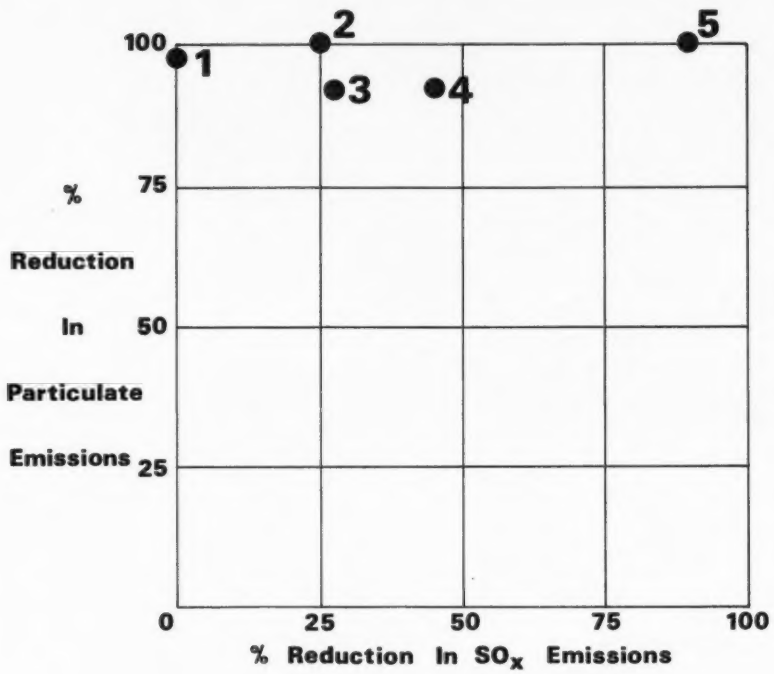
Source Model 1 is an 800 megawatt power plant burning 2% sulfur coal. Alternative 1 reduces particulate emissions by 98% for an estimated cost of $369,000 annually. The low estimate is $139,000 and the high estimate is $741,000. Alternative 1 consists of installing a mechanical collector in series with an electrostatic precipitator and continuing to use the present 2% sulfur coal.

The other alternatives and their estimated costs are:

Alternative 2 - $854,000 annually for substituting lower sulfur, lower ash coal in conjunction with the installation of a mechanical collector in series with an electrostatic precipitator.

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

Source Model 1: POWER PLANT (COAL 800 MW)



Alternative Number	LOW ESTIMATE (000)	Estimated Annual Cost (000)	HIGH ESTIMATE (000)
1	$ 139	$ 369	$ 741
2	441	854	1482
3	847	1323	1918
4	1411	2205	3197
5	1299	3781	7086

Estimated effect: A 99.5% reduction in particulates and a 25% reduction in SO_x emissions.

Alternative 3 - $1,323,000 annually for a fuel switch from present coal to a low sulfur residual oil. Estimated effect: A 92% reduction in particulates and a 27% reduction in SO_x emissions.

Alternative 4 - $2,205,000 annually for a fuel switch from the present coal to an even lower sulfur residual oil than in Alternative 3. Estimated effect: A 92% reduction in particulates and a 45% reduction in SO_x emissions.

Alternative 5 - $3,781,000 annually for the installation of an SO_2 stack gas cleaning system and continuing to use the present coal. Estimated effect: A 99.5% reduction in particulates and a 90% reduction in SO_x emissions.

Next slide, please. (Source Model 2)

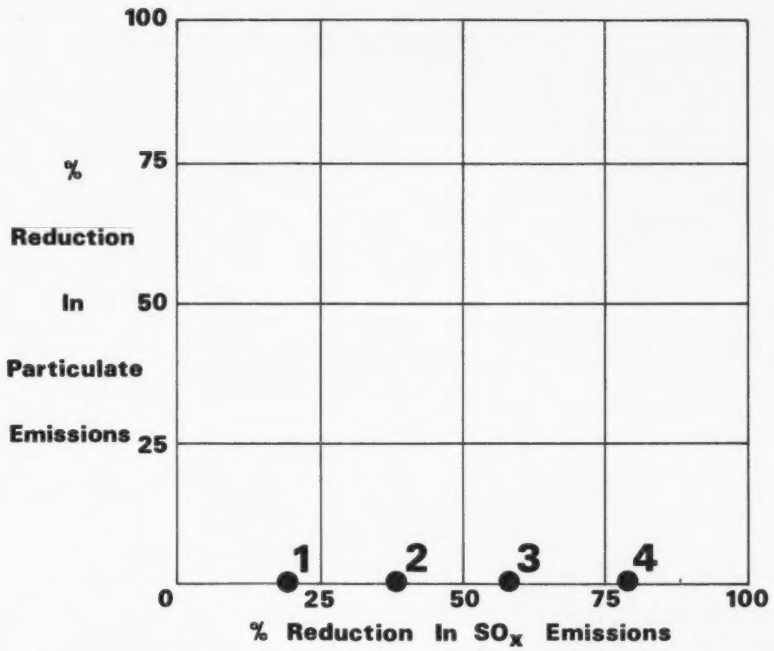
Source Model 2 is also an 800 megawatt power plant but it uses 2.5% sulfur residual oil as its fuel. The estimated annual costs of the four control alternatives increase as the sulfur content of the substituted oil decreases. Since the particulate emission factor of residual oil will probably not change with lower sulfur content, this is a case where all of the cost is allocable to SO_x control. The annual costs range from $630,000 to $5,250,000.

Next slide, please. (Source Model 3)

Source Model 3 is a 200 megawatt power plant burning 2% sulfur coal. The five control alternatives and the emission reductions effected are

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

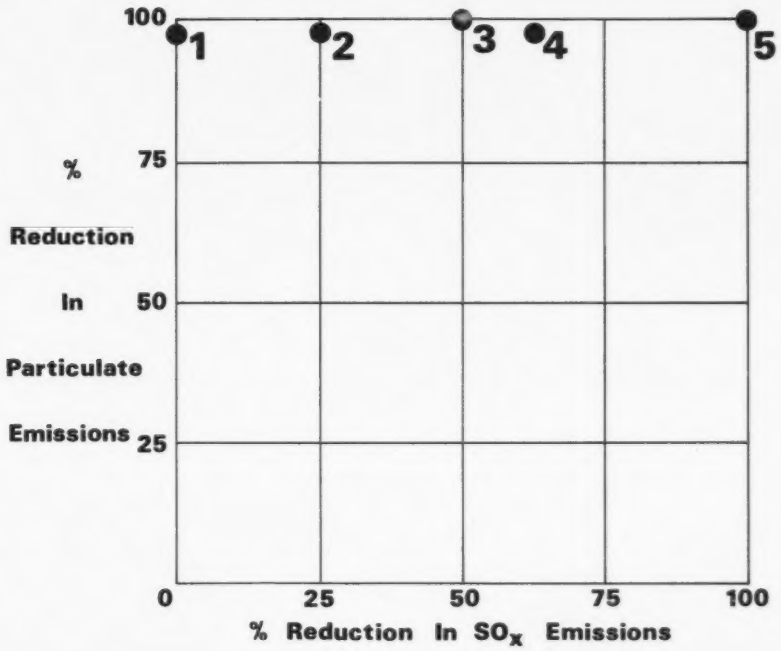
Source Model 2: POWER PLANT (RESIDUAL OIL 800 MW)



Alternative Number	LOW ESTIMATE (000)	Estimated Annual Cost (000)	HIGH ESTIMATE (000)
1	$403	$ 630	$ 914
2	941	1470	2132
3	2150	3360	4872
4	3360	5250	7613
5			

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

Source Model 3: POWER PLANT (COAL 200 MW)



Alternative Number	LOW ESTIMATE (000)	Estimated Annual Cost (000)	HIGH ESTIMATE (000)
1	$ 46	$ 117	$ 241
2	117	228	402
3	622	1021	1568
4	675	1055	1529
5	710	1110	1610

similar to the coal-burning 800 megawatt plant first shown (Source Model 1), except that Alternative 5 is a switch to natural gas. The annual costs range from $117,000 to $1,110,000.

Next slide, please. (Source Model 4)

Here we have the cost estimates for an industrial stationary combustion source model burning 2% sulfur coal with a gross annual input of 100 billion BTU which represents 3,850 tons of coal. The five control alternatives shown span the full range of annual costs.

Alternative 1 - Costing $1,000 annually to substitute a lower sulfur, lower ash coal for the present coal, gives a 6% reduction in particulates and a 25% reduction in SO_x emissions.

Alternative 4 - Costing $22,000 annually to switch from the present coal to 95% natural gas on an interruptible basis and 5% distillate oil, gives a 99.5% reduction in particulates and a 99% reduction in SO_x emissions.

Alternative 5 - Costing $92,000 annually to switch from the present coal to natural gas on a firm basis, produces a negligible quantity of both particulate and SO_x emissions.

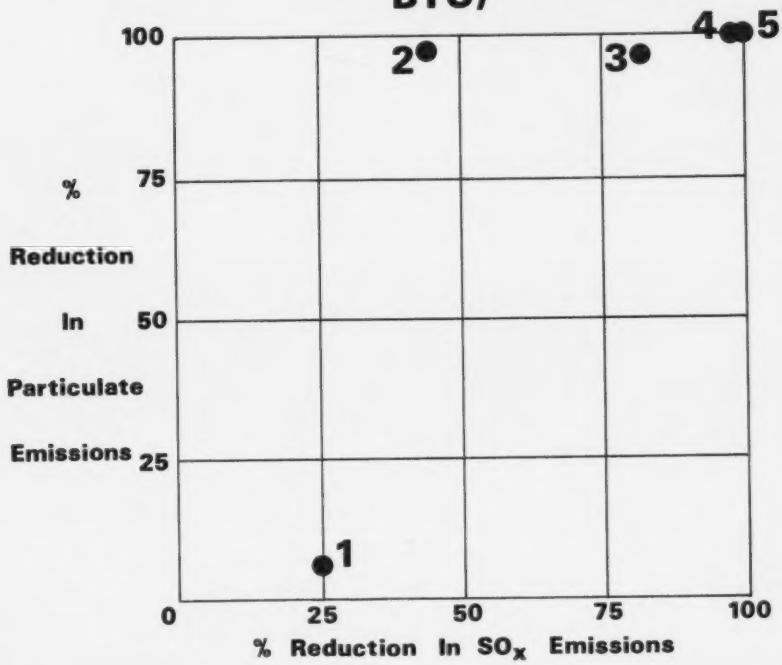
Notice the wide cost disparity between Alternatives 4 and 5, but the small difference in the high percentage of reduction. The disparity is caused by the normally lower rate for obtaining natural gas on an interruptible basis (Alternative 4), rather than on a firm basis (Alternative 5).

Next slide, please. (Source Model 5)

This industrial stationary combustion source model uses 2.5% sulfur residual oil and has a gross annual input of 400 billion BTU (2,700,000 gallons). It has been assumed that this source produces steam to

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

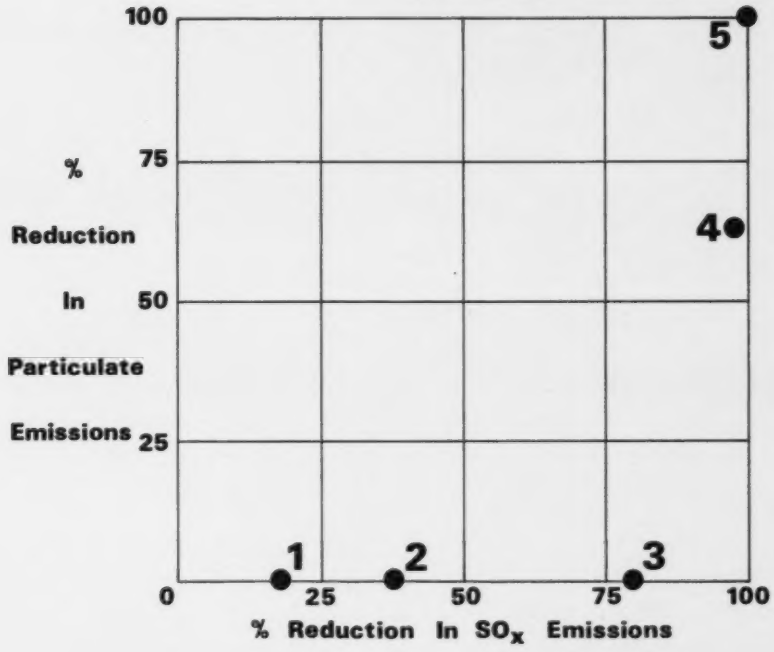
Source Model 4: STATIONARY COMBUSTION (COAL 100 x 10^9 BTU)



Alternative Number	LOW ESTIMATE (000)	Estimated Annual Cost (000)	HIGH ESTIMATE (000)
1	$ 1	$ 1	$ 2
2	5	7	9
3	10	15	21
4	15	22	31
5	59	92	132

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

Source Model 5: STATIONARY COMBUSTION (RESIDUAL OIL 400×10^9 BTU)



Alternative Number	Estimated Annual Cost (000) LOW ESTIMATE (000)		HIGH ESTIMATE (000)
1	$ 3	$ 4	$ 6
2	5	8	12
3	26	40	58
4	33	50	70
5	134	210	304

generate electricity for use in an industrial process. Alternative 1 is substitution of 2% sulfur residual oil for the present 2.5% sulfur oil. Alternative 5 is shutting down the source and purchasing electricity directly from a local utility.

It should be mentioned that Alternative 4, purchasing natural gas on an interruptible basis, creates an apparent distortion in emission reductions. A 63% particulate reduction is shown when switching from 2.5% sulfur residual oil to gas. In Source Model 4, shown previously, switching from 2% coal to natural gas causes a 99% reduction in particulate emissions. The explanation of the difference lies in the fact that for uncontrolled sources the particulate emission rate for coal is higher than that for oil, while the particulate emission rate for natural gas is lower than both. When switching from coal to natural gas the <u>percentage</u> reduction in particulate emissions is greater than when switching from residual oil to natural gas.

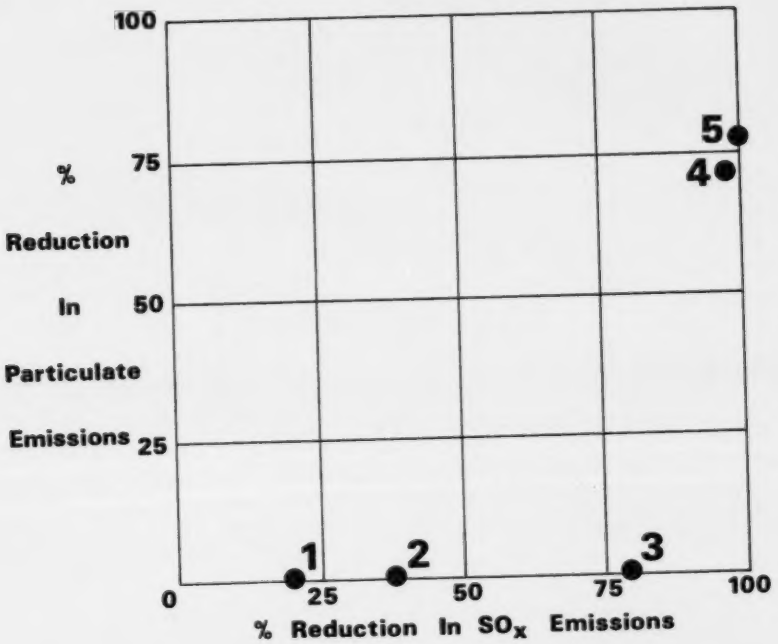
Next slide, please. (Source Model 6)

Here we see the results of an analysis of reducing particulate and SO_x emissions from a model of an apartment house heat generating plant using residual oil with a gross annual input of 50 billion BTU (335,000 gallons). Alternatives 1, 2, and 3 represent the substitution of residual oil of decreasing sulfur content. Alternatives 4 and 5 represent a switch to natural gas on an interruptible and a firm basis, respectively. The annual costs range from $1,000 to $40,000.

Next slide, please. (Source Model 7)

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

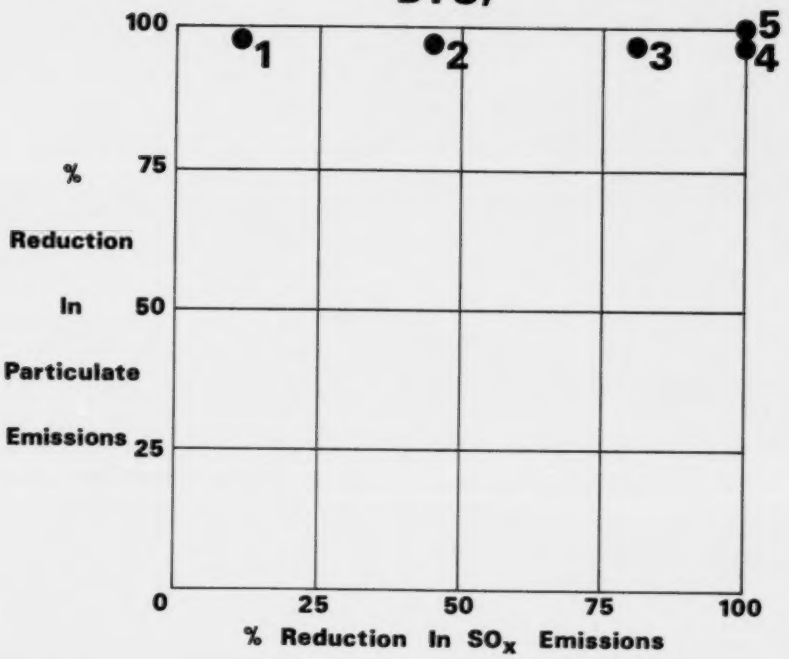
Source Model 6: STATIONARY COMBUSTION (RESIDUAL OIL 50×10^9 BTU)



Alternative Number	Estimated Annual Cost (000) LOW ESTIMATE (000)		HIGH ESTIMATE (000)
1	$ 1	$ 1	$ 1
2	1	2	3
3	4	6	9
4	14	21	29
5	26	40	58

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

Source Model 7: STATIONARY COMBUSTION (COAL 200 x 10^9 BTU)



Alternative Number	Estimated Annual Cost (000) LOW ESTIMATE (000)		HIGH ESTIMATE (000)
1	$ -15	$ -5	$ 7
2	- 6	2	11
3	16	20	24
4	43	62	85
5	95	144	204

This stationary combustion source is a model of a heat generating facility for a commercial establishment. It burns truck-delivered coal with a gross annual input of 200 billion BTU (7,700 tons). Alternative 1, a switch to residual oil, gives a 99% reduction in particulate emissions and an 11% reduction in SO_x emissions. This alternative appears to reduce present annual costs by about $5,000. The reason for this is that the cost of coal delivered to small users, unable to accept large volume rail or barge deliveries, is higher on a BTU basis than residual oil. This result is based upon current New York Area fuel costs as are all other results in this study.

Alternatives 2 and 3 are switches to even lower sulfur content residual oil. Switching to natural gas on an interruptible and a firm basis determines the cost and emission reductions of Alternatives 4 and 5, respectively.

Next slide, please. (Source Model 8)

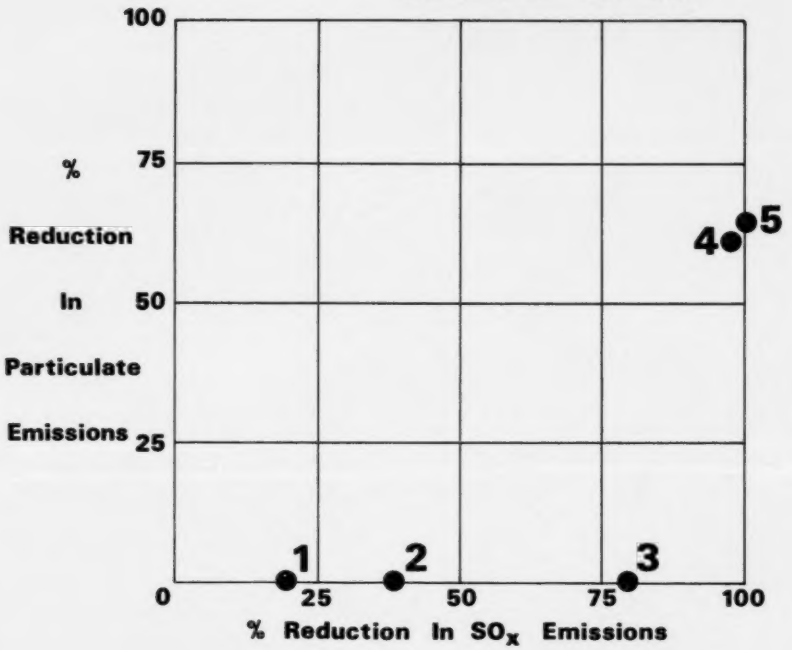
These are the emission reduction and cost results for another commercial stationary combustion source model, using residual oil with a gross annual input of 300 billion BTU (2,000,000 gallons). The estimated annual costs range from $5,000 to $235,000 for the control alternatives analyzed. Alternatives 1, 2, and 3 are substitution of lower sulfur oil, and Alternatives 4 and 5 are switches to natural gas on an interruptible or firm basis, respectively.

Next slide, please. (Source Model 9)

We show now the estimated costs of controlling a municipal incinerator consisting of two refractory furnaces emitting through one stack. Each

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

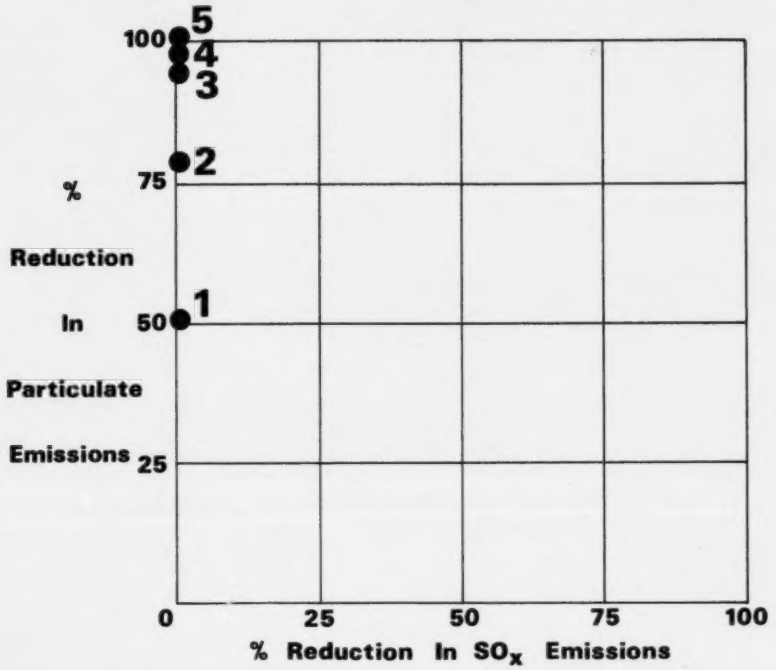
Source Model 8: STATIONARY COMBUSTION (RESIDUAL OIL 300×10^9 BTU)



Alternative Number	Estimated Annual Cost (000) LOW ESTIMATE (000)		HIGH ESTIMATE (000)
1	$ 3	$ 5	$ 7
2	7	11	15
3	24	38	54
4	72	109	154
5	153	235	337

ESTIMATED ANNUAL COSTS OF SO_x AND PARTICULATE EMISSION REDUCTION ALTERNATIVES

Source Model 9: MUNICIPAL INCINERATOR (500 TON/DAY)



Alternative Number	LOW ESTIMATE (000)	Estimated Annual Cost (000)	HIGH ESTIMATE (000)
1	$ 21	$ 60	$ 113
2	25	72	137
3	30	79	159
4	42	122	229
5	50	137	270

furnace burns 250 tons of refuse a day. Alternative 1 is the installation of a baffled spray chamber with a particulate collection efficiency of about 50%. Alternatives 2, 3, and 5 also involve a baffled spray chamber but in series with a cyclone, an electrostatic precipitator, and a fabric filter, respectively. The collection efficiencies are: 78% for Alternative 2, 95% for Alternative 3, and 99% for Alternative 5. Alternative 4 consists of a wet scrubber alone with a collection efficiency of 96%. The annual costs range from $60,000 to $137,000. Subtracting the cost of Alternative 1 from the costs for Alternatives 2, 3, or 5 provides an estimate of the cost of adding a cyclone, ESP, or filter to an incinerator that already has a spray chamber.

In conclusion, I would like to emphasize two factors which should be kept in mind. First, application of the costs presented here to actual sources requires careful consideration of the degree to which these models reflect significant individual realities. We recognize that no two emission sources are identical and that seemingly small differences in physical plant, which are not reflected in a single model, imply, for some control alternatives, significantly different problems of technical and economic feasibility. Second, our calculations do not take into account future price fluctuations, deterioration of equipment, interest rates, and availability of low sulfur, low ash fuels, including natural gas, all of which would have to be reckoned with in a precise determination of costs. But, subject to these factors and to the reliability of the data used, the costs presented here do provide estimates of the <u>magnitude</u> of

incremental annual costs involved and furnish comparative data for achieving reduction of emissions for actual sources which parallel those modeled.

The results would have to be modified, of course, for conditions other than those assumed, but the computerized modeling technique developed to calculate emission control costs has great flexibility as an analytical tool and can be applied to a wide range of emission source configurations and conditions to gain a better understanding of cost-effectiveness relationships.

We hope that the results presented today will be helpful to this conference in developing its recommendations for air pollution abatement in the New York Metropolitan Area. Thank you.

APPENDIX

- Source Model Characteristics
- Description of Emission Control Alternatives

TABLE A-1

SOURCE MODEL CHARACTERISTICS[1/]

SOURCE MODEL	SOURCE MODEL NUMBER	TYPE OF FUEL	GROSS ANNUAL BTU INPUT (BILLIONS)	RATED CAPACITY MEGAWATTS	NUMBER OF FURNACES	SCFM OF EXHAUST GAS VOLUME PER UNIT	FUEL QUANTITY
Power Plant							
	1	Coal (Cyclone)[2/]	44,100	800	4	450,000	1,700,000 tons
	2	Oil[2/]	42,000	800	4	500,000	280,000,000 gals.
	3	Coal (Pulverized Dry Bottom)[2/]	11,100	200	4	140,000	427,000 tons
Stationary Combustion Source							
	4	Coal (Spreader Stoker)	100	N.A.	1	3,100	3,850 tons
	5	Oil	400	N.A.	2	20,000	2,700,000 gals.
	6	Oil	50	N.A.	1	6,300	335,000 gals.
	7	Coal (Spreader Stoker)	200	N.A.	3	25,000	7,700 tons
	8	Oil	300	N.A.	4	37,500	2,000,000 gals.

1/ Developed from information furnished by the U. S. Public Health Service N.Y.-N.J. Abatement Activity.

2/ Furnaces assumed to be capable of using coal, oil or natural gas interchangeably.

N.A. = Not applicable.

TABLE A-2

DESCRIPTION OF EMISSION CONTROL ALTERNATIVES

SOURCE MODEL	ALTERNATIVE	METHOD USED TO REACH REDUCTION	ESTIMATED PERCENTAGE REDUCTION IN EMISSIONS SO_x	PARTICULATE
1	1	Install mechanical collector in series with an electrostatic precipitator.	- %	98.0%
	2	Substitute 1.5% sulfur coal for present 2.0% and install mechanical collector in series with an electrostatic precipitator.	25.0	99.5
	3	Switch to 2.0% sulfur residual oil from present 2.0% sulfur coal.	27.0	92.0
	4	Switch to 1.5% sulfur residual oil from present 2.0% sulfur coal.	45.0	92.0
	5	Install SO_2 stack gas cleaning equipment.	90.0	99.5
2	1	Substitute 2.0% sulfur residual oil for present 2.5% sulfur residual oil.	19.0	-
	2	Substitute 1.5% sulfur residual oil for present 2.5% sulfur residual oil.	38.0	-
	3	Substitute 1.0% sulfur residual oil for present 2.5% sulfur residual oil.	58.0	-
	4	Substitute 0.5% sulfur residual oil for present 2.5% sulfur residual oil.	79.0	-

TABLE A-2 (CONTINUED)

DESCRIPTION OF EMISSION CONTROL ALTERNATIVES

SOURCE MODEL	ALTERNATIVE	METHOD USED TO REACH REDUCTION	ESTIMATED PERCENTAGE REDUCTION IN EMISSIONS SO_x	PARTICULATE
3	1	Install a mechanical collector in series with an electrostatic precipitator.	- %	98.0%
	2	Substitute 1.5% sulfur coal for present 2.0%, and install a mechanical collector in series with an electrostatic precipitator.	25.0	98.0
	3	Substitute 1.0% sulfur coal for present 2.0%, and install a mechanical collector in series with an electrostatic precipitator.	50.0	99.5
	4	Switch to 1.0% sulfur residual oil from present 2.0% sulfur coal.	63.0	99.0
	5	Switch to natural gas on a firm basis from present 2.0% sulfur coal.	99.9	99.7
4	1	Substitute 1.5% sulfur coal for present 2.0%.	25.0	6.0
	2	Switch to 1.5% sulfur residual oil from present 2.0% sulfur coal.	45.0	98.0
	3	Switch to 0.5% sulfur residual oil from present 2.0% sulfur coal.	81.0	98.0
	4	Switch to natural gas on an interruptible basis from 2.0% sulfur coal.	99.0	99.5
	5	Switch to natural gas on a firm basis from 2.0% sulfur coal.	99.9	99.6

TABLE A-2 (CONTINUED)

DESCRIPTION OF EMISSION CONTROL ALTERNATIVES

SOURCE MODEL	ALTERNATIVE	METHOD USED TO REACH REDUCTION	ESTIMATED PERCENTAGE REDUCTION IN EMISSIONS SO_x	PARTICULATE
5	1	Substitute 2.0% sulfur residual oil for present 2.5%.	19.0%	- %
	2	Substitute 1.5% sulfur residual oil for present 2.5%.	38.0	-
	3	Substitute 0.5% sulfur residual oil for present 2.5%.	79.0	-
	4	Switch to natural gas on an interruptible basis from present 2.5% sulfur residual oil.	99.0	63.0
	5	Terminate own generation of electric power, and purchase electric power from a utility.	100.0	100.0
6	1	Substitute 2.0% sulfur residual oil for present 2.5%.	19.0	-
	2	Substitute 1.5% sulfur residual oil for present 2.5%.	38.0	-
	3	Substitute 0.5% sulfur residual oil for present 2.5%.	79.0	-
	4	Switch to natural gas on an interruptible basis from 2.5% sulfur residual oil.	99.0	71.0
	5	Switch to natural gas on a firm basis from 2.5% sulfur residual oil.	99.9	76.0

TABLE A-2 (CONTINUED)

DESCRIPTION OF EMISSION CONTROL ALTERNATIVES

SOURCE MODEL	ALTERNATIVE	METHOD USED TO REACH REDUCTION	ESTIMATED PERCENTAGE REDUCTION IN EMISSIONS SO_x	PARTICULATE
7	1	Switch to 2.5% residual oil from present 2.0% coal.	11.0%	99.0%
	2	Switch to 1.5% residual oil from present 2.0% coal.	45.0	99.0
	3	Switch to 0.5% residual oil from present 2.0% coal.	81.0	99.0
	4	Switch to natural gas on an interruptible basis from present 2.0% coal.	99.9	97.0
	5	Switch to natural gas on a firm basis from present 2.0% coal.	99.9	99.6
8	1	Substitute 2.0% sulfur residual oil for present 2.5%.	19.0	-
	2	Substitute 1.5% sulfur residual oil for present 2.5%.	38.0	-
	3	Substitute 0.5% sulfur residual oil for present 2.5%.	79.0	-
	4	Switch to natural gas on an interruptible basis from present 2.5% sulfur residual oil.	99.0	61.0
	5	Switch to natural gas on a firm basis from present 2.5% sulfur residual oil.	99.9	64.0

TABLE A-2 (CONTINUED)

DESCRIPTION OF EMISSION CONTROL ALTERNATIVES

SOURCE MODEL	ALTERNATIVE	METHOD USED TO REACH REDUCTION	ESTIMATED PERCENTAGE REDUCTION IN EMISSIONS SO_x	PARTICULATE
9	1	Install a baffled spray chamber.	- %	50.0%
	2	Install a baffled spray chamber in series with a mechanical collector.	-	78.0
	3	Install a baffled spray chamber in series with an electrostatic precipitator.	-	95.0
	4	Install a wet scrubber.	-	96.0
	5	Install a baffled spray chamber in series with a fabric filter.	-	99.0